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SPECIFICATION

Mobile Telecommunication Antenna and Mobile Telecommunication Apparatus Using the Same

TACHNICAL FIELD

The present invention relates to a mobile telecommunication antenna used in a portable telephone or the like and a mobile telecommunication apparatus equipped with the mobile telecommunication antenna.

BACKGROUND ART

Mobile telecommunication apparatuses such as portable telephones or pagers have rapidly been commercialized. Fig. 40 illustrates a common portable telephone as a mobile telecommunication apparatus.

As shown, reference numeral 10 denotes a portable telephone, and reference numeral 11 denotes a case of it. Antenna 5 is disposed in parallel with the longitudinal direction of case 11 and extending outwardly from case 11. Antenna 5 is joined at one end with power supply 13 mounted in the case for feeding a high-frequency signal. In the figure, reference numeral 1 denotes a microphone, reference numeral 2 denotes an operation unit, reference numeral 3 denotes a display, and reference numeral 4 denotes speaker.

In such a conventional construction of the portable telephone, the extending antenna declines portability as a portable telephone accordingly declines. Also, the antenna is fragile and may be easily broken by any abrupt shock, for example, in dropped down.

In the manufacturing process of the portable telephones, the antenna has to be mounted to the case by manually tightening screws. The process can be hardly automated thus increasing the overall cost of manufacturing.

Also, the conventional telephone construction requests the antenna and a high-frequency circuit to be electrically connected to each other by a dedicated a connecting component, which possibly claims the cost-up, causes the power loss, and thus is also unfavorable in the electrical characteristics.

DISCLOSURE OF THE INVENTION

The present invention eliminates the foregoing problems, and the object of the invention is to provide a mobile telecommunication antenna enhancing the portability, the durability of a mobile telecommunication apparatus such as a portable telephone, mass-productivity, and the electrical characteristics. And also, the object is to provide a mobile telecommunication apparatus employing the antenna.

For achieve the object of the present invention, the antenna does not project outwardly from the case of the mobile communication apparatus, and the antenna is accommodated in the case. That results to enhance the portability and durability of the apparatus. Also, the antenna is formed in a chip size, thus improving the mass-productivity and the electrical characteristics thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view of a portable telephone according to Embodiment 1 of the present invention;

Fig. 2 is a radiation pattern of an antenna having a radiation-conductive element of substantially 1/2 wavelength according to the same

mbodiment;

Fig. 3 is a radiation pattern of a conventional antenna, shown in Fig. 40, having a radiation-conductive element of substantially 1/2 wavelength;

Fig. 4 is a schematic view showing the telephone according to the same embodiment in its actual use;

Fig. 5 is a radiation pattern of the antenna having a radiation conductive element of substantially 1/2 wavelength in its actual use according to the same embodiment;

Fig. 6 is a radiation pattern of the conventional antenna having a radiation conductive element of substantially 1/2 wavelength in its actual use;

Fig. 7 is a radiation pattern of the antenna having a radiation-conductive element of substantially 1/4 wavelength according to the same embodiment;

Fig. 8 is a radiation pattern of the conventional antenna having a radiation-conductive element of substantially 1/4 wavelength;

Figs. 9(a) and 9(b) are a perspective view and a cross sectional view of an antenna according to Embodiment 2 of the present invention;

Fig. 10 is a perspective view showing a modification of the antenna according to the same embodiment;

Fig. 11 is a perspective view showing another modification of the antenna according to the same embodiment;

Fig. 12 is a perspective view showing a further modification of the antenna according to the same embodiment;

Figs. 13(a) and 13(b) are a perspective view and a cross sectional view showing a still further modification of the antenna according to the same embodiment;

Figs. 14(a) and 14(b) are a perspective view and a cross sectional view showing a still further modification of the antenna according to the same embodiment;

Fig. 15 is a perspective view showing a still further modification of the antenna according to the same embodiment;

Fig. 16 is a perspective view showing a still further modification of the antenna according to the same embodiment;

Fig. 17 is a perspective view showing a still further modification of the antenna according to the same embodiment;

Figs. 18(a) and 18(b) are a perspective view and a cross sectional view showing a still further modification of the antenna according to the same embodiment;

Figs. 19(a) and 19(b) are a perspective view and a cross sectional view showing a still further modification of the antenna according to the same embodiment;

Fig. 20 is a perspective view showing a still further modification of the antenna according to the same embodiment;

Fig. 21 is a perspective view showing a still further modification of the antenna according to the same embodiment;

Figs. 22(a) and 22(b) are a perspective view and a cross sectional view showing a still further modification of the antenna according to the same embodiment;

Figs. 23(a) and 23(b) are a perspective view and a cross sectional view showing a still further modification of the antenna according to the same embodiment;

Fig. 24 is a perspective view showing a still further modification of the antenna according to the same embodiment;

Fig. 25 is a perspective view showing a still further modification of the antenna according to the same embodiment;

Fig. 26 is a perspective view showing a still further modification of the antenna according to the same embodiment;

Figs. 27(a) and 27(b) are a perspective view and a cross sectional view showing a still further modification of the antenna according to the same embodiment;

Figs. 28(a) and 28(b) are a perspective view and a cross sectional view showing a still further modification of the antenna according to the same embodiment;

Fig. 29 is a perspective view of an installed antenna according to Embodiment 3 of the present invention;

Fig. 30 is a perspective view showing a modification of the installed antenna according to the same embodiment;

Figs. 31(a) and 31(b) are a schematic view and a partial cross sectional view showing the antenna installed into a portable telephone according to the same embodiment;

Fig. 32 is a schematic view of the portable telephone in use according to the same embodiment;

Fig. 33 is a perspective view showing a further modification of the installed antenna according to the same embodiment;

Figs. 34(a) and 34(b) are a perspective view and a partial cross sectional view showing a further modification of the installed antenna installation according to the same embodiment;

Fig. 35 is a perspective view of an antenna according to Embodiment 4 of the present invention;

Fig. 36(a) is an impedance characteristic of the antenna according to

the same embodiment, and Fig. 36(a) is an impedance characteristic of the conventional antenna shown in Fig. 39;

Fig. 37 is a perspective view showing another modification of the antenna according to the same embodiment;

Fig. 38 is a perspective view showing a further modification of the antenna according to the same embodiment;

Fig. 39 is a perspective view of a conventional antenna; and

Fig. 40 is a perspective view of another conventional antenna.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

(Embodiment 1)

Fig. 1 is a schematic view of a portable telephone according to Embodiment 1 of the present invention. Reference numeral 10 denotes a portable telephone, reference numeral 11 denotes its case. Antenna 12 having a radiation-conductive element is mounted in case 11 substantially vertical to the longitudinal direction of case 11 and not project outwardly from case 11. Antenna 12 is jointed at one end to power supply 13 mounted in case 11 for feeding a high-frequency signal. Reference numeral 1 denotes a microphone, reference numeral 2 denotes an operation unit, reference numeral 3 denotes a display, and reference numeral 4 denotes a speaker.

As shown, antenna 12 is disposed in case 11 substantially vertical to the longitudinal direction of case 11. That results that the telephone has no projecting portion, enhances its portability, and is protected from broken..

Fig. 2 illustrates a radiation pattern of antenna 12 having a radiation-conductive element of substantially 1/2 wavelength. For comparison, Fig. 3 illustrates a radiation pattern of a conventional antenna (of which radiation-conductive element has 1/2 wavelength) disposed vertical to the

longitudinal direction of the case as shown in Fig. 40. In common, portable telephone 10 is sensitive to a vertically polarized wave along the Z-axis radiated from case 11 and a horizontally polarized wave along the Y-axis radiated from the radiation-conductive element of antenna 12.

In comparison, the antenna according to this embodiment exhibits a sensitivity greater than or equal to -10 (dBd) to five different polarized waves, i.e., two in the XY plane, two in the ZX plane, and one horizontally polarized wave in the YZ plane as shown in Fig. 2. The conventional antenna exhibits a sensitivity greater than or equal to -10 (dBd) to three different polarized waves, i.e., one vertically polarized wave in the XY plane, one horizontally polarized wave in the YZ plane, and one horizontally polarized wave in the ZX plane as shown in Fig. 3. The antenna according to this embodiment works in more polarization planes, and its antenna characteristic is reduced in a declination in actual use.

As an antenna at a base station for the portable telephones is disposed generally in vertical, a vertically polarized wave often reach the portable telephones or mobile communication apparatuses. The antenna according to this embodiment enables to minimize declination in the sensitivity to the vertical polarized wave in actual use. This will be explained in more detail referring to Fig. 4 where the portable telephone is positioned in actual use corresponding to an ear and a mouth of a user.

As shown, portable telephone 10 in the use is tilted about 60° from the vertical, and its antenna characteristic to the vertically polarized wave may accordingly be declined. The radiation-conductive element of antenna 12 mounted in vertical to the longitudinal direction of case 11 is tilted only 30° from the vertical direction. Consequently, its antenna characteristic for the vertical polarized wave does not decline in actual use as compared with the

conventional antenna, which is disposed in parallel with the longitudinal direction of the case.

Fig. 5 shows a radiation pattern of the antenna of the portable telephone operated at the position shown in Fig. 4. Fig. 6 shows that of the conventional portable telephone for comparison. As shown, a pattern average gain (PAG) to a vertically polarized wave of the portable telephone according to this embodiment in actual use is about 3 (dBd) higher.

Moreover, as the radiation-conductive element of antenna 12 is located at the upper end in case 11, it may hardly be covered with a hand of the user. That reduces a declination in the antenna characteristic caused by the user's body.

The radiation-conductive element is located at the upper end in the case, its electrical length is set to substantially an n/2 wavelength (where n is an odd number), and consequently, a current hardly runs along the case. Accordingly, even if the hand grips the case, an impedance change of the antenna as well as an attenuation of the antenna radiation is reduced, and. the antenna characteristic is favorably reduced in a declination.

Also, the radiation-conductive element disposed substantially in vertical to the longitudinal direction of the case works as an antenna not only for the vertically polarized wave but also for the horizontally polarized wave. Consequently, the antenna characteristic is reduced in the declination in actual use.

Fig. 5 shows an antenna radiation pattern of antenna 12 having the radiation conductive element of substantially 1/4 wavelength. For comparison, fig. 8 shows an antenna radiation pattern of the conventional antenna (of which radiation conductive element has substantially a 1/4 wavelength) disposed in vertical to the longitudinal direction of the case. As

shown in comparing these, substantially the same radiation characteristic as of the projecting antenna is obtainable even if the antenna having the radiation-conductive element is disposed in substantially vertical to the longitudinal direction of the case, and a portability of a mobile telecommunication apparatus is improved thanks to the non-projecting antenna,.

When the electrical length of the radiation conductive element is substantially an n/4 wavelength (where n is an odd number), a more current runs through the case. This causes the antenna impedance to be changed when the case is gripped by the hand, hence making the impedance matching difficult and making the antenna radiation unfavorable. Accordingly, the antenna characteristic may marginally be declined. On the contrary, the impedance of the antenna is close to 50Ω when the case is not touched by the hand, and thus, a matching circuit can be omitted. The fabricating process hence increases in the efficiency and decreases in the cost.

(Embodiment 2)

The construction of antenna 12 shown in Fig. 1 will be described in more detail referring to Figs. 9 through 28. The antenna construction here is designed for transmitting and receiving signals in two different frequency bands, but not limited to it. Throughout the drawings, like components are denoted by like numerals, and their description will not be repeated.

In Fig. 9, reference numeral 12 denotes an antenna. First radiation-conductive element 15 is arranged in a helical form in dielectric substrate 14 and second radiation-conductive element 16 is arranged in a zigzag, meander form on the top of or within the dielectric substrate 14 over first radiation-

conductive element 15.

First radiation conductive element 15 and second radiation conductive element 16 are insulated from each other while only first radiation conductive element 15 is connected to power supply terminal 13a for feeding a high-frequency signal.

Second radiation conductive element 16 is fed with a high-frequency signal by an electromagnetic coupling effect with first radiation conductive element 15. This allows first radiation-conductive element 15 and second radiation-conductive element 16 to resonate at different frequencies, thus permitting to transmit and receive signals at each two different frequency, respectively.

Dielectric substrate 14 is formed by laminating plural dielectric layers and assembling them to a single unit. Patterns of conductors and relevant through-holes at specific positions on specific layers are arranged to form desired shapes of first radiation conductive element 15 and second radiation conductive element 16. Other modifications of this embodiment described blow are also implemented through forming first radiation conductive element 15 and second radiation conductive element 16 of desired shapes.

The first and second radiation-conductive elements may be accompanied with a third, a fourth, and more radiation-conductive elements which are disposed at different locations and electrically insulated from the first and second radiation-conductive elements. And the antenna can accordingly transmit and receive signals at a more number of frequency bands. The radiation-conductor elements may be selected from helical elements, meander elements, linear elements, sheet elements, cylindrical elements, and their combinations.

Accordingly, while the apparatus is capable of transmitting and

receiving the plural frequency bands of signals, its overall dimensions can significantly be reduced.

The antennas shown in Figs. 9 through 14 commonly comprise first radiation conductive element 15 formed of a helical element connected to power supply terminal 13a for feeding a high-frequency signal, second radiation conductive element 16 formed of a meander element of zigzag shape. Those differ from each other in the relationship between positions of first radiation conductive element 15 and second radiation conductive element 16.

More specifically, Fig. 9 illustrates the helical axis of helical element 15 and the zigzag direction of meander element 16 both arranged substantially in parallel with the longitudinal direction of dielectric substrate 14. Fig. 10 shows the elements are arranged substantially orthogonal to the longitudinal direction.

Fig. 11 illustrates the helical axis of helical element 15 arranged substantially in parallel with the longitudinal direction of dielectric substrate 14 while the zigzag direction of meander element 16 arranged substantially orthogonal to the longitudinal direction. Fig. 12 is the reverse to that, where the helical axis of helical element 15 arranged substantially orthogonal to the longitudinal direction of dielectric substrate 14 while the zigzag direction of meander element 16 is arranged substantially in parallel with the longitudinal direction.

Fig. 13 illustrates meander element 16 disposed along the center of the helical element 15 while two elements 15 and 16 are arranged as shown in Fig. 9. Fig. 14 illustrates meander element 16 located on the side of helical element 15.

The antennas shown in Figs. 15 through 18 commonly comprise first

radiation-conductive element 17 and second radiation-conductive element 18 both arranged of a helical shape, where only first radiation conductive element 17 is connected to power supply terminal 13a for feeding high-frequency signals. Those differ from each other in the relationship between positions of first radiation conductive element 17 and second radiation conductive element 18.

More specifically, Fig. 15 shows the helical axis of first helical element 17 and the helical axis of second helical element 18 both arranged substantially in parallel with the longitudinal direction of dielectric substrate 14. Fig. 16 shows both elements arranged substantially orthogonal to the longitudinal direction.

Fig. 17 shows that the helical axis of first helical element 17 is arranged substantially orthogonal to the longitudinal direction of dielectric substrate 14, and the helical axis of second helical element 18 is arranged substantially in parallel with the longitudinal direction. Fig. 18 shows that helical element 18 disposed along the center of the helical shape of helical element 17 while two elements 17 and 18 are shaped as shown in Fig. 15.

The antennas shown in Fig. 19 through 22 commonly comprise first radiation conductive element 19 and second radiation conductive element 20 both arranged of a meander shape, where only first radiation conductive element 19 is connected to power supply terminal 13a for feeding a high-frequency signal. Those differ from each other in the relationship between positions of first radiation conductive element 19 and second radiation conductive element 20.

More specifically, Fig. 19 shows the zigzag directions of first meander element 19 and second meander element 20 both arranged substantially in parallel with the longitudinal direction of dielectric substrate 14. Fig. 20

shows the elements are arranged substantially orthogonal to the longitudinal direction.

Fig. 21 shows that the zigzag direction of first meander element 19 is arranged substantially in parallel with the longitudinal direction of dielectric substrate 14, and the zigzag direction of second meander element 20 is arranged substantially orthogonal to the longitudinal direction. Fig. 22 shows two meander elements 19 and 20 disposed orthogonal to the bottom of dielectric substrate 14 while two elements 19 and 20 are shaped as shown in Fig. 19.

The antennas shown in Figs. 23 through 28 commonly comprise first radiation-conductive element 21 formed of a zigzag, meander shape connected to power supply terminal 13a for feeding a high-frequency signal and second radiation-conductive element 22 is formed of a helical shape. Those differ from each other in the relationship between positions of first radiation-conductive element 21 and second radiation-conductive element 22.

More specifically, Fig. 23 shows the zigzag direction of meander element 21 and the helical axis of helical element 22 both arranged substantially in parallel with the longitudinal direction of dielectric substrate 14. Fig. 24, like Fig. 9, shows both arranged substantially in orthogonal to the longitudinal direction.

Figs. 23 and 24 where power supply terminal 13a is connected to meander element 21 differs from Figs. 9 and 10 where power supply terminal 13a is connected to helical element 15.

Fig. 25 shows that the zigzag direction of meander element 21 is arranged substantially in parallel with the longitudinal direction of dielectric substrate 14, and the helical axis of helical element 22 is arranged

substantially in orthogonal to the longitudinal direction. Fig. 26, in reverse to that, shows that the zigzag direction of meander element 21 is arranged substantially in orthogonal to the longitudinal direction of dielectric substrate 14, and the helical axis of helical element 22 is arranged substantially in parallel with the longitudinal direction

Figs. 25 and 26 where power supply terminal 13a is connected to meander element 21 differs from Figs. 11 and 12 where power supply terminal 13a is connected to helical element 15.

Fig. 27 illustrates meander element 21 disposed in helical element 22 while elements 21 and 22 are disposed as shown in Fig. 23. Fig. 28 illustrates meander element 21 disposed on the side of helical element 22 in the same construction.

(Embodiment 3)

The installation of antenna 12 shown in Fig. 1 will be specifically described referring to Figs. 29 through 34. The installation of the antenna operable to transmit and receive signals in two different frequency bands, respectively, but is not limited to that. Throughout the drawings, like components are denoted by like numerals, and their description will not be repeated.

In Fig. 29, reference numeral 12 denotes an antenna. In the antenna, first radiation-conductive element 23 is formed of a helical shape on the surface of core member 33 made of dielectric material, magnetic material, or insulating resin material, and second radiation-conductive element 24 is formed of a zigzag meander shape insulated from first radiation-conductive element 23.

Also, only first radiation conductive element 23 is connected to power

supply terminal 13a for feeding a high-frequency signal. Matching circuit 14 is connected between power supply terminal 13a and power supply 13. Matching circuit 14 may comprise chip capacitors, chip inductors, or reactance elements, e.g. a circuit pattern on printed circuit board 8. Matching antenna 12 with power supply 13 reduces the power loss of reflections.

Core member 33 made of a dielectric material shortens its electrical length due to a wavelength-shortening effect on the dielectric material thus contributing to the smaller size of antenna 12. Antenna 12 having core member 33 made of magnetic material, antenna 12 is favorable for low-frequency signals.

In case that core member 33 is made of an insulating resin material, antenna 12 may be fabricated at higher efficiency. First radiation conductive-element 23 and second radiation-conductive element 24 are placed in advance at such locations as to realize a desired antenna characteristic and are encapsulated with the resin material by mold forming. First and second radiation-conductive elements 23, 24 may be shaped by pressing process. The whole manufacturing process can accordingly be easily automated with high productivity.

The relationship between positions of first radiation-conductive element 23 and second radiation-conductive element 24 may be modified for controlling the strength of electromagnetic coupling. This facilitates to adjust the impedance in the respective frequency band. Also, the antenna construction according to this embodiment is favorable for modifying the relationship between positions of the first and second radiation conductive elements.

The installation of antenna 12 will now be explained. Antenna 12

comprises three mounting terminals 25 formed on the bottom and sides thereof for being easily mounted on printed circuit board 8. Power supply terminal 13a is also formed over the bottom and a side of antenna 12. On the other hand, on printed circuit board, mounting lands 26 and power supply land 27 are formed on the corresponding four locations. Antenna 12 is securely soldered at the four locations, together with other components, to printed circuit board 8 by an automatic mounting technique.

Fig. 30 is a perspective view explaining a modification of the antenna installation. As shown, power supply terminal 28a connected to first radiation-conductive element 23 is formed on one end of core member 33, and mounting terminal 29a is formed on the other end. Power supply jig 28b and mounting jig 29b corresponding to the terminals, respectively, are provided on printed circuit board 8. The antenna is mounted8, power supply terminal 28a and mounting terminal 29a are put in and fixed to jigs 28b and 29b, respectively.

Consequently, antenna 12 is securely mounted by employing a simple arrangement, prevented from exposing to high temperatures in the reflow process, and thus, made of low fusing point material. And its characteristic is thus hardly declined.

Fig. 31 illustrates a schematic plan view and a partially cross sectional view of a portable telephone to which the antenna is installed. Fig. 32 is a schematic view illustrating an example of the actual use of the portable telephone.

As shown, antenna 12 is mounted at the upper end on printed circuit board 8 embedded in case 11 of portable telephone 10. More specifically, antenna 12 is mounted on the opposite side to speaker 4 of printed circuit board 8 so that the antenna is distanced from head 6 of the user as much as

possible when speaker 4 is put to the ear during his/her talking.

This reduces the power loss caused by the influence of head 6 and thus maintains the antenna radiation characteristics. This also reduces an unfavorable influence by holding case 11 with a hand.

Antenna 12 can locate far from an interruptive object, e.g. shield cover 9 for electrically shielding a high-frequency circuit or grounding patterns formed on printed circuit board 8. This reduces an electrical coupling with the object, the power loss caused by the electrical coupling, and thus declination of the antenna characteristics.

Fig. 33 is a perspective view illustrating another modification of the antenna installation. As shown, power supply terminal 34 connected to first radiation-conductive material 31 is formed on one end of the surface of core member 33 having a round shape in cross section thereof, and mounting terminal 37 is formed on the other end. Each terminal is designed so as to hold printed circuit board 8. Printed circuit board 8 has an opening formed therein operable to accommodate antenna 12. Power supply lands 36 and mounting lands 37 corresponding respectively to power supply terminal 34 and mounting terminal 35 are formed on both sides of printed circuit board 8. Power supply terminal 34 and mounting terminal 35 are soldered to their corresponding lands 36 and 37 so that antenna 12 can be securely fixed to printed circuit board 8.

For accommodating antenna 12, the opening formed in printed circuit board 8 according to this embodiment may be replaced by a notch of the same size provided in the upper end of printed circuit board 8. Also, the mounting terminal and the mounting land are not limited to one pair but two or more pairs so as to fix the antenna more securely.

Fig. 34 is a perspective view showing a further modification of the

antenna installation. As shown, power supply terminal 34 connected to first radiation-conductive material 31 is provided on one end region of the surface of core member 33 having a round shape in cross section thereof, and three mounting terminals 35 are provided on the remaining region with an equal interval. Each terminal is designed so as to hold printed circuit board 8. Power supply lands 36 and mounting lands 37 corresponding to power supply terminal 34 and mounting terminals 35 respectively are provided on both sides of printed circuit board 8. Power supply terminal 34 and mounting terminals 35 are soldered to corresponding lands 36 and 37 so as to fix the antenna to printed circuit board 8 securely.

The arrangements shown in Figs. 33 and 34 permit the space in upper portion of case 11 to be used effectively, and the antenna characteristic is improved.

(Embodiment 4)

Specific constructions of antenna 12 shown in Fig. 1 will be described referring to Figs. 35 through 39. The antenna is operable to transmit and receive signals in two different frequency bands, respectively, but is not limited to that. Throughout the drawings, like components are denoted by like numerals, and their description will not be repeated.

In Fig. 35, reference numeral 40 denotes an inverted-F shaped antenna. Reference numeral 41 denotes a grounding substrate having a metal material provided at least on the surface thereof. Reference numeral 42 denotes a first radiation-conductive element arranged in parallel with and electrically connected to grounding substrate 41. Reference numeral 43 denotes a second radiation-conductive element arranged in vertical to grounding substrate 41 and electrically connected to first radiation-

conductive element 42. Reference numeral 44 denotes a power supply feeding the radiation conductive-element with a high-frequency signal. And reference numeral 45 denotes a short-circuit element for connecting inverted-F shaped antenna 40 to grounding substrate 41.

Fig. 36(a) illustrates an impedance profile of the inverted-F shaped antenna, and Fig. 36(b) illustrates an impedance profile of a conventional inverted-F shaped antenna shown in Fig. 39. As compared, the profile of the inverted-F shaped antenna according to this embodiment exhibits a wider range of frequencies. The wider frequency range results because second radiation-conductive element 43 arranged substantially in vertical to grounding substrate 41 makes an impedance matching easier.

As second radiation-conductive element 43 is arranged substantially in vertical to grounding substrate 41, the overall area can be decreased. That reduces accordingly the interference with the antenna of the hand of a user, holding the telephone.

Fig. 37 illustrates a modification of the inverted-F shaped antenna according to this embodiment. Reference numeral 46 denotes a dielectric body, where first and second radiation-conductive elements 42, 43 are formed on the surface of dielectric body 46 and coupled to power supply 44 through matching circuit 47 consisting of at least one reactance device.

This antenna becomes smaller because of the wavelength-shortening effect of dielectric body 46. As matching circuit 47 connected to power supply 44 ensures impedance matching, the antenna frequency range successfully increases. Matching circuit 47 may be implemented by chip components or a printed circuit pattern.

First and second radiation-conductive elements 42, 43 are not limited to be deposed on the surfaces of dielectric body 46 but may be embedded in

dielectric body 46 with the same effect. Also, dielectric body 46 may be replaced by a magnetic body.

Fig. 38 illustrates another modification of the inverted-F shaped antenna having first radiation-conductive element 42 having a meander shape. The meander shape of first radiation-conductive element 42 lowers the resonance frequency, hence contributing to reduce the size of antenna 40.

While first radiation-conductive element 42 arranged in parallel with grounding substrate 41 is formed a meander shape in this modification, second radiation-conductive element 43 arranged vertical to grounding substrate 41 or both the radiation-conductive elements may be formed of a meander shape.

INDUSTRIAL APPLICABILITY

As set forth above, the antenna according to the present invention is mounted in substantially vertical to the longitudinal direction of a case of a mobile telecommunication apparatus, thus eliminating an undesired projecting portion on the case. This improves the portability of the mobile telecommunication apparatus, and minimizes its broken-down at any accident such as dropping down. Also, this allows the antenna to function for not only vertically polarized waves but also horizontally polarized waves to the case hence minimizing a declination in the antenna characteristic. Moreover, the antenna can be reduced to a chip size thus improving its mass-productivity and the electrical characteristics.